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An illustration of how to evaluate alternative methods of solving forage supply problems associated with expanding a dairy herd.

NORTHEAST REGIONAL PUBLICATION

New Hampshire Agricultural Experiment Station
College of Agriculture
University of New Hampshire

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Northeast Regional Publication

This is the second report of the Technical Committee of Northeast Regional Research Project NE-33, "Economics of Irrigation on Northeastern Farms". The first report was *Farm Management Research Methods in Irrigation Problems*, Northeast Regional Publication No. 33, Storrs (Connecticut) Agricultural Experiment Station, April 1958.

Numerous other reports have been published by the individual member states in conjunction with their contributing projects. State publications include information on the costs and returns of irrigating vegetables, tobacco, forage and potatoes.

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Technical Committee of Northeast Regional Research Project NE-33, Economics of Irrigation on Northeastern Dairy Farms

Storrs, Connecticut ..... Marvin Kottke
Delaware ..... William McDaniel
Maine ..... W. E. Pullen
Massachusetts ..... B. D. Crossmon
New Jersey ..... John Carncross
New York ..... B. F. Stanton
Pennsylvania ..... Robert McAlexander
Rhode Island ..... Niels Rorholm
West Virginia ..... George Toben
United States Department of Agriculture
Agricultural Research Service ..... H. L. Stewart
State Experiment Station Division ..... R. J. Saville
Administrative Advisor ..... Harry Keener, *Director*
New Hampshire Agricultural Experiment Station

Evaluating the Profitability of Irrigation on Northeastern Dairy Farms[1]

Introduction

WHAT is the place of irrigation on northeastern dairy farms? How does the use of irrigation compare with other methods for adjusting to greater forage needs? A single answer to each of these questions, which applies to all farms, does not exist. There are too many important price and resource differences from farm to farm. For example, the price of hay may range from $20 to $40 a ton within one state in the same year. Buying extra hay may be feasible in one case and much more questionable in the other. The cost and availability of water are two more obvious considerations. On some farms located near major streams or lakes, water is always readily available at low cost. On others considerable effort and money are required to provide water for irrigation.

One of the purposes of this bulletin is to point out the more important factors which a dairyman must consider before buying an irrigation system. The capital investment and costs of operating typical irrigation systems will be presented. An indication of some of the results obtained from controlled experiments using irrigation in different parts of the Northeast will be given. The first part of the bulletin is intended to show what kinds of information will be needed to make an evaluation of irrigation.

Knowing how much irrigation will cost is useful. An idea of the kinds of increases in yields which may result over a period of years from irrigation is necessary. But equally important is a good idea of how irrigation compares with other methods of providing more forage for more milking cows. The major part of this bulletin is devoted to this problem. How does one go about comparing irrigation with other alternatives? What are the major alternatives to irrigation? What happens when these alternatives are compared for a typical farm situation? Presentation of a method of finding answers to these last three questions is the primary objective of this report. Irrigating a forage crop will be compared with:

(1) Feeding green-chop (also known as soilage or zero-grazing).
(2) Buying replacement heifers instead of raising them.
(3) Applying a higher level of fertilizer.
(4) Replacing corn grain with corn silage.
(5) Buying additional hay.
(6) Renting additional hay and pasture land.
(7) Feeding additional grain to replace forage.

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[1] Prepared by a NE-33 subcommittee composed of: Marvin Kottke, Robert McAlexander, Niels Rorholm and B. F. Stanton, respectively of the State Agricultural Experiment Stations of Storrs (Connecticut), Pennsylvania, Rhode Island, and New York. Acknowledgement is made for the assistance on budgeting analysis received from Francis Montville of the Rhode Island Agricultural Experiment Station.

Results from research on the economics of irrigation conducted in nine of the northeastern states provide the basis for most of this discussion. Data on costs and returns from irrigation have been developed in each of the respective states. The basic method of analysis presented here represents a synthesis of the ideas of the research workers in the respective states of the Northeastern region.

The Basic Problem

The irrigation of forage crops makes it possible to harvest more feed per given area of land, and hence makes it possible to feed more cows from this land. Size is important in today's dairy farming. While there is no guarantee that a large dairy farm will make more money than a small one, a larger farm has a better chance of paying for the needed improvements and machinery for modern farming.

Expanding a farm's volume of business also helps an operator make greater use of his existing resources. Traditionally a farmer's earnings for his labor and management are "what is left" after the cash costs and a charge for his investment are subtracted from income. If an increase in size of business does not add more to income than expenses, then such a use of resources is not justified.

Keeping more cows is one means of expanding volume. Keeping better producing cows is another means. The trend is toward using both and both require more feed. Forage plays a vital role in dairy feeding. Thus a search for additional forage accompanies expansion on most dairy farms. In much of the Northeast the problem is complicated by the fact that the land needed for expansion is becoming relatively scarce. Hence, the customary method of expanding size of operations by adding more land may become less of a possibility. For this reason questions are being raised about the profitability of several alternative methods of obtaining the extra forage needed to expand a dairy business. In this bulletin, emphasis is placed on the alternative of irrigation, but others are also considered in comparison.

Irrigation Requirements and Returns

As a starting point in considering irrigation, a farmer will want to collect as much information as possible in order to make a wise decision. Every irrigation system should be individually designed by a competent engineer to meet the specific needs of a given farm. He needs to know how much investment and resources it will take and how it will affect forage yields.

What Does It Take to Irrigate?

The initial requirement is an adequate source of water. If water is available then the next consideration is the physical condition of the soil and the kind of crop grown. It is assumed in this bulletin that the reader has already obtained the necessary physical and technical information or will turn to other sources for it.[1] To proceed then, he next will want to know how much investment will be required.

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[1] Technical information on the design of irrigation systems is available in *Irrigation Guides,* published by the Soil Conservation Service. Departments of Agronomy and Engineering of the College of Agriculture also provide such information. Irrigation equipment companies will provide information on their particular systems.

Table 1. Typical Sizes of Irrigation Systems and Their Investment Values on Dairy Farms.

Acres Irrigated	Motor Size (Horsepower)	Aluminum Pipe (Feet)	Sprinklers (No.)	Sprinklers (Size)	Investment in System[1] (Dollars)
		Connecticut Survey Data, 38 Farms[2]			
17	40	1,900	10	1″	4,090
40	50	2,150	12	1″	4,808
75	80	2,700	16	1″	5,494
120	100	3,000	2	giant	6,410
		Pennsylvania Budgeted Data — Individual Farms[3]			
10	8.3	920	*	*	1,284
20	16	1,100	*	*	2,238
30	28	1,640	*	*	3,301

[1] Exclusive of the costs of developing a source of water.

[2] Source: Kottke, M. W., *Capital and Labor Efficiency in Irrigation*, Storrs (Connecticut) Agricultural Experiment Station Bulletin 345, May 1959, pp. 4 and 14.

[3] Source: Unpublished data prepared by the Department of Agricultural Economics, Pennsylvania State University.

* Not given.

Investment. The initial outlay for a system will run between $1,200 and $6,500. Some typical irrigation systems used on several different sized dairy farms are shown in Table 1. A survey of farms using irrigation indicated that the average investment required to irrigate 40 acres in 1957 was $4,808. Operations almost twice as large only required about $700 more investment. Smaller systems specifically designed for certain farms were estimated to be as low as $1,284 for a 10 acre operation. Proper design of a system may help to minimize total investment. The amount required for each farm depends upon not only the number of acres irrigated but also the distance from water source to fields, the size pipe used and the size of motor required.

Irrigation crop equipment, of course, lasts over a period of years. Thus, this sizeable initial outlay would not have to be made again for an irrigation system for perhaps 10 to 20 years. Instead of looking at the initial outlay, it would be well to convert the ownership cost to an annual basis. For a 40 acre operation the annual ownership cost in terms of depreciation, interest, taxes and insurance averages about $575.

Fuel Cost. The main cash operating cost is fuel. Depending on how frequently one irrigates and on how much water is applied the fuel consumption rate varies between 20 and 30 gallons per acre (Table 2).

As an example, a farmer's yearly fuel costs for irrigating 40 acres could be expected to be about $250. On the different sized operations it varies from an average of $90 to an average of $480.

Labor Requirement. One of the obstacles to irrigation in the past was the hard work and time-consuming task of moving pipe in the fields. The

Table 2. Fuel Consumption and Cost for Typical Dairy Farm Irrigation Systems (Survey Data).[1]

Acres Irrigated	Fuel Consumption Per Acre	Fuel Consumption Per Farm	Total Fuel Cost Per Farm*
17	27	460	$ 90
40	31	1,240	250
75	20	1,500	300
120	20	2,400	480

* At $.20 per gal.

[1] Source: Kottke, M. W., *Capital and Labor Efficiency in Irrigation*, Storrs (Connecticut) Agricultural Experiment Station Bulletin 345, May 1959, pp. 15 and 17.

Table 3. Labor Requirements for Typical Dairy Farm Irrigation Systems (Survey Data).[1]

Acres Irrigated	Moving Hrs. Per Acre	Total Moving Hrs. Per Farm	Moving Between Fields, Preparing & Storing Hrs.	Total Hrs. Per Farm
17	3.7	65	39	104
40	3.1	125	33	158

[1] Source: Kottke, M. W., *Capital and Labor Efficiency in Irrigation*, Storrs (Connecticut) Agricultural Experiment Station Bulletin 345, May 1959, p. 15.

introduction of portable aluminum pipe has eliminated some drudgery. Still it takes time to move the aluminum pipe from one setting to another. On the average it takes about three hours per acre to set and move pipe. Again this varies depending upon the frequency of irrigation, the size of pipe, and area covered per setting.

If additional labor has to be hired because of irrigation, then the annual cash costs will be increased by that amount. On the other hand, if a farm's present labor force can do the irrigating then there will be no extra cash costs, but doing the irrigation job may mean taking it away from other work. If it is taken away from income producing work, then the income foregone is an opportunity cost to irrigation.

What Yield Response to Expect from Irrigation

What one needs to know in order to determine the profitability of irrigation is how much it will increase yields. One way of looking at this is to consider how much of a valuable crop irrigation will save during a year of low rainfall. Another way to assess its value is to look at how much it will increase yields on the average over a period of years.

Data from controlled experiments on forage irrigation can give an indication of what results one might expect from irrigation. A review of

controlled experiments in the Northeastern states reveals a wide range in results. They show a range from decreased yields to an excess of a ton and a half of dry matter per acre.[1] The average appears to center between 800 and 1200 pounds of dry matter per acre. These statements are based upon the summarization of the results of a series of experiments conducted in Delaware, New York, Pennsylvania and Rhode Island during the period 1947-48.

Few of the controlled experiments were exactly alike in terms of the species of crop grown, amount of rainfall, amount of fertilizer applied and type of soil. This accounts, in part, for the wide range in results and, therefore, the suggested average of about 1,000 pounds per acre increase in yield must be looked upon as only a rough indication of what irrigation will do. It is recommended that farmers obtain yield information from their own Experiment Stations and other sources within their own areas. If possible, farmers should obtain yield information from sources that have similar conditions to those of their own farms.

With regard to kinds of crops irrigated it was noted that orchard grass responded more vigorously to irrigation and held stands more effectively than did the other grasses. Brome grass, except when accompanied by alfalfa, did not respond as well as the average of all species. Alfalfa and the alfalfa mixtures were perhaps the most variable respondents to irrigation.

Budgeting Irrigation's Effect on Income for a Particular Farm Situation

Once a person has collected information on what is needed and what irrigation will do, then he is in a position to make an estimate of how his income will be affected if he decides to adopt the practice. Making such an estimate is called *partial budgeting*. It is a method of checking the profitability of a new practice before committing oneself to making the change.

To illustrate this method a particular farm situation is chosen. It is a typical Northeast dairy farm. Many farmers have similar situations and probably are facing a similar problem to one discussed here. This illustration will not give an answer for all cases, but it will demonstrate the manner in which individuals can make evaluations of their own particular situations.

Basic Farm Situation

The farm consists of 150 acres of land, including 75 acres of cropland, 70 acres of forest land and five acres of farmstead. The cropland is of moderate fertility and depth, medium textured, well-drained and suitable for irrigation. A stream bordering the farm would supply an adequate amount of water for irrigating up to 45 acres of forage crops.

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[1] Weights were in oven-dried matter. When converted to field cured weight, one ton of oven-dried matter equals about 1.2 tons of field cured weight with 17 percent moisture.

Table 4. Average Value of Inventory of Land, Buildings, Livestock and Machinery of the Basic Farm.

Item	Average Value
Land:	
150 acres (75 acres cropland)	$23,000
Buildings:	
Barn (25 cow capacity), milkhouse, and silo	8,000
Livestock:	
25 cows at $350/head	8,750
12 replacements averaging $150/head	1,800
Machinery:	
1 tractor, 3-plow	1,650
Tillage and planting equipment	1,100
Mower and rake	413
Hay baler and blower	1,650
Manure spreader and loader	454
Miscellaneous	756
Total machinery	$ 6,023

Table 5. Cropping Program of the Basic Farm.

Item	Acres	Yield per Acre	Total Production
Permanent pasture	10	1.2 tons H.E.*	12 tons H.E.*
Corn grain	15	60 bushels	900 bushels
Oat silage	15	7 tons	105 tons
Alfalfa-orchard grass	45	3 tons	135 tons

* Hay equivalent consumed by livestock on pasture.

The farm is a one-man operation with the operator providing an average of 260 hours of labor per month. His present operations take all of his labor time except for about 340 hours. Most of this available labor time occurs during the fall and winter months. Hired labor is available at $1.25 per hour, if needed. The operator hires all grain and silage harvesting, but has adequate machinery for all other farm operations (Table 4). Sufficient barn and feed storage space is available for a 25 cow dairy herd plus replacements. Any expansion of the herd will require building an addition to the barn.

A rotation of one year of corn for grain, one year of oats for silage, and three years of alfalfa-orchard grass is followed presently on the cropland. Present production provides enough forage for 25 dairy cows producing 10,000 pounds of milk per cow, and 12 replacements.

The annual costs and returns for the present plan on this farm are shown in Table 6. Basic data used for computing costs and returns are shown in

Table 6. Annual Income of the Basic Farm.

Returns		
Milk sales, 250,000 lbs. @ $5.00/cwt.	$12,500	
Livestock (culls), 5 @ $168	1,390	
Corn grain, 62 bu. @ $1.35/bu.	84	
Total		$13,974
Expenses		
Crops		
Fertilizer, 11.2 tons @ ave. $65/ton	$ 726	
Seed, 165 lbs. corn, 645 lbs. oats, 225 lbs. alf.-orch.	229	
Fuel and lub., 1,680 gal. fuel @ $.16, lub. $13	285	
Machine hire	188	
Miscellaneous	304	
Livestock		
Feed. 8.94 tons 36% prot. conc. @ $90/ton and misc.	$ 964	
Breeding and veterinary, 25 @ $11.20/cow and repl.	280	
Milk testing and marketing, 25 @ $26/cow and repl.	650	
Miscellaneous, 25 @ $31/cow and repl.	775	
Other		
Machinery repair, $6,023 ave. value x 4%	$ 241	
Building repair, $8,000 ave. value x 2%	160	
Taxes	352	
Depreciation, bldgs. @ 3%, machinery $924	1,164	
Interest, 5% of $47,580	2,379	
Total		$ 8,697
Net return to labor and management		$ 5,277

the Appendix. The returns to labor and management under the present plan are about $5,277. How can this farm expand its volume of business and increase its net income? The following sections will deal with some possible solutions to this question.

Estimated Change in Net Income from Adding Irrigation

By partial budgeting, it is possible to determine the effect on farm organization and returns from irrigating the 45 acres of alfalfa-orchard grass. Based on the information presented in the "Yield Response" section, it is assumed that yields may be increased 0.5 to 1.0 ton per acre on the average. When there is a significant range it is well to budget both the low and the high yield estimates. A response of 0.5 ton per acre produces 22.5 additional tons which will permit an addition of three cows and 1.5 replacements.[1] A response of 1.0 ton per acre is sufficient to add seven cows and 3.5 replacement heifers. Irrigation costs come to about $914 which is the same for either the low or high response (Table 7). To this must be added the costs of keeping and feeding the extra cows and the costs of harvesting the extra forage. Subtracting the change in expenses from the

[1] Fractional units are used in the computations to simplify the balancing of feed requirements and supplies. In actual practice, a farmer might add two replacements one year and one the next year which on the average is 1.5 replacements per year.

Table 7. Estimated Change in Annual Net Returns from Adding an Irrigation System and Expanding Herd Size—(A) Three Cows Added with 0.5 Ton Response, (B) Seven Cows Added with 1.0 Ton Response.

	Price or Rate	Yield Response to Irrigation (A) 0.5 Ton per Acre Quantity	(A) 0.5 Ton per Acre Value	(B) 1.0 Ton per Acre Quantity	(B) 1.0 Ton per Acre Value
Changes in Returns					
Milk sales	$5.00/cwt.	30,000 lbs.	$1,500	70,000 lbs.	$3,500
Livestock (culls)	168 each	.6	100	1.4	235
Hay	35/ton	3.6	126	.9	32
Total			$1,726		$3,767
Changes in Expenses					
Crops:					
Irrigation: Equipment	[a]	[a]	$ 575	[a]	$ 575
Fuel	.20/gal.	1,620 gal.	324	1,620 gal.	324
Oil and grease			14		14
Harvesting: Fuel, lub. and misc.			29		57
Livestock:					
Purchased feed	75/ton	5 ton	375	11.7 ton	878
Breeding and vet.	11.20/cow and repl.	3	34	7	78
Milk testing and marketing	26/cow	3	78	7	182
Miscellaneous	31/cow and repl.	3	93	7	217
Other:					
Labor	1.25/hr.	114 hrs.	143	202 hrs.	252
Building repairs	2%	[b]	21	[c]	50
Taxes	40 mills	[b]	21	[c]	50
Depreciation	3%	[b]	32	[c]	74
Interest	5%	[b]	53	[c]	123
Total			$1,792		$2,874
Estimated Change in Net Return to Labor and Management			—$ 66		+$ 893

[a] The amount invested in irrigation equipment is $4,808. Annual depreciation, interest, repairs and insurance based on this amount equals $575.
[b] Addition to the barn has an average value of $1,050. Depreciation, taxes, repairs and interest are based on this amount.
[c] Addition to the barn has an average value of $2,450. Depreciation, taxes, repairs and interest are based on this amount.

change in returns one obtains the change in net income. For this particular situation net income is decreased by $66 if the response is 0.5 ton per acre and increased by $393 if the response is 1.0 ton per acre.

An estimate of the profitability of adding an irrigation system to expand the dairy farm has now been established. It appears that irrigation must increase yields by more than 0.5 ton per acre in order to be profitable. If this particular farmer can be reasonably confident of increasing his yields 1.0 ton per acre by irrigation, then it looks like a good production adjustment for him.

However, he has one other important question to answer before he makes a decision. Are there other feasible adjustments that are more profitable than irrigation and its accompanying changes in farm organization? In subsequent sections several alternative adjustments will be budgeted to illustrate how to find answers to this latter question.

Budgeting Other Alternatives for a Particular Farm

It has been shown for this particular farm situation that possibly seven cows could be added and farm profits could be increased by irrigating forage crops if yield response is 1.0 ton per acre. Irrigation can help the farmer increase size. But so can any other practice that increases the production of forages, or otherwise enables the dairy farmer to increase his output of milk.

Feeding Green-Chop (Also Known as Soilage or Zero-Grazing)

By feeding the cows green-chop, rather than following conventional pasture methods, less land is needed for summer feeding of the milking herd. By keeping the cows off the land it is possible to feed the same number of cows on twenty-five to thirty percent less acreage. In the present situation two additional cows can be summer-fed on six acres less. This makes it possible to shift six acres into hay production for winter forage for the additional cows.[1] This of course involves additional expenses. The farmer following green-chop practices must own a field chopper. This farmer does not; hence, it has to be bought. Once purchased, operating expenses have to be paid and depreciation and interest charged. This also means that it is no longer necessary for the farmer to custom hire the silage operation on his oats field, so he saves a certain amount of money here. The two additional cows will raise his expenses for housing and caring for the cows on a proportionate basis. Table 8 shows the changes that one might expect in this base situation if a farmer introduced green-chop feeding of the cows in the summertime and expanded his herd by two cows. The net increase in returns to labor and management is $52.

If the farmer had enough time to follow a green-chop program without hiring extra labor, the increase would be $315 greater. If he already owned the chopper, it would be still greater. Individual situations will dictate the specific changes in income possible from such a technique.

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[1] For this case it is assumed that 24 acres of the alfalfa-orchard grass is being pastured at present. In the change to green-chop, 18 acres will be pastured and the other six will be harvested as hay.

Table 8. Estimated Change in Annual Net Returns from Changing to Green-Chop Feeding (soilage or zero grazing) in Place of Conventional Pasturing—Two Cows Added.

Changes in Returns		
Milk sales	$1,000	
Livestock (culls)	111	
Corn grain	— 84	
Total		$1,027
Changes in Expenses		
Crops: Fuel and lub.	$ 27	
Machine hire	— 113	
Livestock: Feed	78	
Breeding and vet.	23	
Milk testing and marketing	52	
Miscellaneous	62	
Other: Machinery repairs	63	
Building repair	14	
Taxes	22	
Hired labor	315	
Depreciation	283	
Interest	149	
Total		$ 975
Estimated Change in Net Return to Labor and Management		+$ 52

Buying Replacement Heifers Instead of Raising Them

Another possibility for increasing the output of milk from a farm is to purchase replacements rather than to raise them. This frees a certain amount of building space, labor and home grown feeds which then can be used for the milking herd. In this situation the farmer has an average of twelve replacements of various ages. Home grown feeds, notably forage required for these replacements will provide feed for an additional six milking cows, increasing herd size from 25 to 31 cows. It will be assumed that the space vacated by the young stock would provide room for an additional three cows, hence, additional building charges will only have to be charged for the remaining three cows. Milk receipts for the additional six cows amount to $3,000 per year (Table 9). Assuming that each cow has roughly a five-year productive life, the farmer would have to buy six replacements annually at a cost of $2,100. Adding to that some minor elements of cost, there appears to be a difference in favor of purchasing replacements at $310.

This change does not affect the amount of labor hired nor does it affect materially the capital required to operate the farm. This method of providing replacements would not be particularly desirable for someone interested in selling breeding stock. Some people would also object that the purchasing of replacements is more likely to increase the incidence of disease. Studies have not shown that farms that purchase their replacements have any more disease than farms that raise their own, however.

Table 9. Estimated Change in Annual Net Returns from Changing to Purchasing Replacements Instead of Raising Them—Six Cows Added.

Changes in Returns		
Milk sales	$3,000	
Livestock (culls)	— 42	
Corn grain	— 14	
Total		$2,944
Changes in Expenses		
Livestock: Feed	—$ 34	
Breeding and vet.	67	
Milk testing and marketing	156	
Purchase replacements (6)	2,100	
Miscellaneous	186	
Other: Building repair	21	
Taxes	10	
Depreciation	62	
Interest	66	
Total		$2,634
Estimated Change in Net Returns to Labor and Management		+$ 310

Table 10. Estimated Change in Annual Net Returns from Applying More Fertilizer—Nine Cows Added.

Changes in Returns		
Milk sales	$4,500	
Livestock (culls)	500	
Corn grain	100	
Total		$5,100
Changes in Expenses		
Crops: Fertilizer (7.6 ton)	$ 492	
Fuel and lub.	23	
Machine hire	22	
Miscellaneous	32	
Livestock: Feed	342	
Breeding and veterinary	101	
Milk testing and marketing	234	
Miscellaneous	279	
Other: Building repair	63	
Taxes	50	
Hired labor	139	
Depreciation	94	
Interest	337	
Total		$2,208
Estimated Change in Net Returns to Labor and Management		+$2,892

Applying a Higher Level of Fertilizer Application

An obvious way of increasing crop yields, and thereby herd size, is by increasing the level of fertilizer application. In this example an additional $492 is spent on fertilizer, increasing the total corn production by 375 bushels and the hay equivalent by 50 tons. This amounts to a one ton increase per acre for hay and a 25 bushel increase per acre for corn. This allows for an increase in the herd size of nine cows and three replacements. Not only is there more milk for sale, but there is also additional corn left over for cash sale, totaling an increase of $5,100 in receipts. Other than the expense for fertilizer, the major increases on the expense side are connected with caring for the nine additional cows. This is reflected not only in increased concentrate purchases but also in increased amounts of hired labor, depreciation and interest charges. The result is a rather favorable increase in the net returns to labor and management of $2,892.

Some qualifications may be in order with respect to the high fertilizer situation. Just as for this basic farm situation, many farmers may find that greater use of fertilizer is one of their most profitable alternatives. But it should be realized that the effect on net income will vary according to yield responses to fertilizer just as it varies for irrigation according to yield response. Also, it is well to note in this illustration that the other parts of the farm business were figured to efficiently utilize the added yield. Unless the other parts are run efficiently the farmer would simply waste the added forage by putting it into cows that are not properly cared for, properly milked, and properly housed. It should also be cautioned that in certain years serious lack of moisture can eliminate completely the possible gains from higher fertilizer applications. The present example, however, should be practical on many farm situations.

Replacing Corn Grain with Corn Silage

Producing corn silage instead of corn grain will increase the roughage supply on this farm by about 180 tons of silage which is equivalent to about 60 tons of hay. This change means that the farmer now has to purchase grain instead of raising it. By utilizing the extra 60 tons of hay equivalent and by feeding purchased grain, 9 cows and 5 replacements can be added to the herd.

It will take practically the same amount of labor to produce silage as it does to produce corn grain. The main differences in costs are more machine hire, more grain, the added livestock and the addition to the barn. This farm's net returns to labor and management would increase by about $584 if this change is made.

Buying Hay

An obvious way of increasing the carrying capacity of a given farm is to simply purchase hay in addition to what can be raised on the farm itself. This change does not involve or limit the number of cows that can be added to the herd, but for purposes of comparison, it has been assumed that the farmer adds five cows.[1] To add five cows and two replacements

[1] The number of cows added for this alternative is arbitrary, but the choice of five helps to keep the magnitude of this change somewhat comparable to the irrigation alternative.

Table 11. Estimated Change in Annual Net Returns from Replacing Corn Grain with Corn Silage—Nine Cows Added.

Changes in Returns		
Milk sales	$4,500	
Livestock (culls)	500	
Corn grain	— 84	
Total		$4,916
Changes in Expenses		
Crops: Fuel and lub.	—$ 12	
Machine hire	105	
Livestock: Feed	3,020	
Breeding and veterinary	101	
Milk testing and marketing	234	
Miscellaneous	279	
Other: Building repair	63	
Taxes	50	
Hired labor	61	
Depreciation	94	
Interest	337	
Total		$4,332
Estimated Change in Net Returns to Labor and Management		+$ 584

Table 12. Estimated Change in Annual Net Returns from Buying Additional Hay—Five Cows Added.

Changes in Returns		
Milk sales	$2,500	
Livestock (culls)	278	
Corn grain	— 84	
Total		$2,694
Changes in Expenses		
Livestock: Feed	$ 562	
Hay purchased (31 ton)	1,080	
Breeding and veterinary	56	
Milk testing and marketing	130	
Miscellaneous	155	
Other: Building repair	35	
Taxes	28	
Hired labor	23	
Depreciation	52	
Interest	190	
Total		$2,311
Estimated Change in Net Returns to Labor and Management		+$ 383

requires a purchase of 31 tons of hay which at $35 per ton amounts to about $1,080. The cropping program and, hence, crop expenses are unaffected. The milk sales and cull sales increase by well over $2,500, while the corn grain sales are eliminated. Expenses in addition to the cost of the hay are those associated with keeping and feeding five extra cows. The result is a net increase of $383.

Renting or Buying Additional Land

Instead of purchasing hay, the farmer might choose to rent or buy additional land if the opportunity presented itself. In this case it is assumed that 12 acres can be rented and the rental rate is $25 per acre.[1] The extra forage from these 12 acres permits an addition of five cows and two young stock to the herd. Such an increase in land area would typically increase the efficiency with which machinery and equipment are utilized in that, within limits, land may be increased without thereby increasing the need for new and larger machines. Typically, also, the available power is sufficient

Table 13. Estimated Change in Annual Net Returns from Renting Twelve Acres of Additional Land—Five Cows Added.

Changes in Returns		
Milk sales	$2,500	
Livestock (culls)	278	
Corn grain	— 65	
Total		$2,713
Changes in Expenses		
Crops: Fertilizer	$ 107	
Seed	37	
Fuel and lub.	43	
Machine hire	32	
Rented land (12 acres)	300	
Miscellaneous	48	
Livestock: Feed	214	
Breeding and veterinary	56	
Milk testing and marketing	130	
Miscellaneous	155	
Other: Building repair	35	
Taxes	28	
Hired labor	91	
Depreciation	52	
Interest	190	
Total		$1,518
Estimated Change in Net Return to Labor and Management		+$1,195

[1] Annual ownership costs of land valued at $300 per acre are about equivalent to a rental rate of $25. Whether to own or to rent also depends upon other factors such as availability of land for sale or rent, tenure security desired, amount of investment capital available, and degree of decision-making freedom desired. Ownership cost is also affected by inflation or deflation.

to take care of moderate increases in land area. As indicated in Table 13 the rental of twelve additional acres of land results in additional returns to labor and management of $1,195.

Feed More Grain and Less Hay

More cows can be fed on a given area of forage by reducing the amount of hay fed and increasing the grain ratio. In the basic situation the grain ratio was one pound of grain to four pounds of milk. By increasing grain feeding to one pound of grain for each two and one-half pounds of milk, enough hay can be saved to increase the herd size by three cows and two replacements. Receipts increase by $1,583; however, expenses go up by more than that leaving a net loss in returns to labor and management of $109. In this situation it would not pay to increase grain feeding by that much; but it is possible that it would pay to change the ratio to 1 to 3 or 1 to 3½. This, however, would not change the number of cows in the herd sufficiently to provide a realistic example. It is probably true that the ratio at which grain is fed is more properly related to the prices of grain, of hay and of milk; keeping the utilization of a given forage supply as only a secondary factor in this respect.

Table 14. Estimated Change in Annual Net Returns from Feeding More Grain and Less Hay—Three Cows Added.

Changes in Returns		
Milk sales	$1,500	
Livestock (culls)	167	
Corn grain	— 84	
Total		$1,583
Changes in Expenses		
Livestock: Feed	$1,297	
Breeding and veterinary	34	
Milk testing and marketing	78	
Miscellaneous	93	
Other: Building repair	21	
Taxes	18	
Depreciation	31	
Interest	120	
Total		$1,692
Estimated Change in Net Returns to Labor and Management		—$ 109

Summary and Comparison of the Alternatives in Terms of Changes in Number of Cows, Net Returns, Investment and Labor Requirements

How to get more forage and expand the herd size of a particular Northeast dairy farm is investigated from the standpoint of several different production possibilities in this report. The partial budgets indicate that adding irrigation may be profitable but that other alternatives may also be profitable. This is what the farmer finds when he weighs the merits of the several alternatives in terms of their effects upon net income. In addition, he will want to look at the capital and labor requirements needed to make the changes. A summary type comparison for this purpose is shown in Table 15.

In doing the partial budgeting it was assumed that sufficient capital and labor could be obtained to make any of the changes under consideration. Nevertheless, the farmer might prefer a less profitable production change to a more profitable one if the capital and labor requirements of the less profitable one are decidedly lower. Furthermore, in many realistic situations limitations on the availability of capital and labor play an important part on farmers' choices of production practices.

This farmer would probably take note of the comparatively high capital investment and labor requirements needed to make the change to irrigation. Also, the income prospects for irrigation are not as great as some of the other alternatives. From the income standpoint, the "high fertilizer" and "rent land" alternatives look good. Part of the reason for favorable returns

Table 15. Changes in Number of Cows, Net Returns, Investment and Labor Requirements by Alternatives.

Alternative	No. of Cows	Changes in: Net Returns to Operator Labor and Management	Changes in: Investment	Changes in: Labor Requirement
		(Dollars)	(Dollars)	(Hours)
A. Irrigation:				
.5 ton yield response	3	— 66	6,983	324
1.0 ton yield response	7	893	9,883	508
B. Green-Chop (soilage, zero-grazing)	2	52	2,988	440
C. Purchase Replacements	6	310	1,350	0
D. High Fertilizer	9	2,892	6,750	418
E. Corn Silage	9	584	6,750	333
F. Buy Hay	5	383	3,800	200
G. Rent Land	5	1,195	3,800	340
H. Feed More Grain	3	— 109	2,400	120

on these two is that they offer an opportunity for utilization of the present crop machinery and some other fixed resources more fully. If this farmer wanted to expand his milking herd with a minimum of new capital investment and without hiring extra labor, then the "purchase replacements" looks like the alternative for him. The point is that in making an evaluation of several production alternatives a farmer will base his final decision on the profitability prospects, on his capital and labor situation and on the amount of risk he is willing to take.

Throughout this report emphasis has been placed on the evaluation of individual production practices. Actually some combination of the several alternatives may be the best solution for this farm. For example, if the farmer applies more fertilizer, rents additional land, and replaces his corn grain with corn silage, he can almost double his herd size. Another combination might include adding irrigation, applying more fertilizer, and purchase replacements instead of raising them. Again the availability of capital and labor plays an important part in the selection of some combination of alternatives. When major expansions and adjustments are under consideration, the problem may involve a different scale of production techniques than those presented for this problem. But whether the adjustment under consideration is large or small, the method of evaluation as illustrated in this report applies equally well.

Appendix Table 1. Inventory of Machinery and Equipment.

Item	Estimated Cost	Life in Years	Depreciation per year[a]	Average Value[b]
Machinery and Equipment:				
Tractor, 3 plow	$3,000	10	$270.00	$1,650.00
Plow, 3-12″	375	12	28.12	206.25
Disc, 7½′-double	400	12	30.00	220.00
Harrow, springtooth	125	15	7.50	68.75
Cultivator, 2-row	250	10	22.50	137.50
Corn planter, 2-row	300	15	18.00	165.00
Grain drill, with grass seeder	550	15	33.00	302.50
Mower, 7′	325	8	36.56	178.75
Rake, side delivery	425	12	31.88	233.75
Hay baler	2,250	10	202.50	1,237.50
Blower	750	10	67.50	412.50
Manure spreader	525	15	31.50	288.75
Manure loader	300	10	27.00	165.00
Sprayer	200	10	18.00	110.00
2 Wagons	400	12	30.00	220.00
Dairy equipment and other	525		47.25	288.75
Small tools	250		22.50	137.50
Total	$10,950		$923.81	$6,022.50

[a] Depreciation equals (original price less ten percent of original price) divided by (estimated life in years).

[b] Average value equals (original price plus ten percent of original price) divided by two.

Appendix Table 2. Labor Allowances for Crops and Dairy Cows.[1]

Item	Labor Period				Total
	April-May	June-July	Aug.-Sept.	Oct.-Mar.	
			(Hours)		
Allowances per Acre:					
For Crops:					
Corn grain	4.2	1.2	2.4	5.0	12.8
Corn silage	4.0	2.0	0	5.0	11.0
Oats silage	3.5	0.7	0	0	4.2
Alf-orch hay	0.2	3.1	4.7	0.7	8.7
Alf-orch hay (high fert.)	0.2	3.6	5.5	0.7	10.0
Alf-orch hay (irrigated)	0.2	5.6	7.5	0.7	14.0
Allowances per Dairy Cow:					
Plus Replacement:					
25 cow herd	15	10	10	50	85
Each additional cow up to 15	6	5	5	24	40
Total Labor Allowances:					
Permanent pasture	5	0	0	0	5
Corn grain (15 ac.)	63	18	36	75	192
Oats silage (15 ac.)	53	11	0	0	64
Alf-orch grass (45 ac.)	9	140	212	32	393
Dairy cows (25 head)	375	250	250	1250	2125
Total	505	419	498	1357	2779
Operator Labor Available	520	520	520	1560	3120

[1] Based on unpublished data, Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University.

Appendix Table 3. Prices for Inputs and Products.

Item	Unit	Price
Fertilizer and Seed:		
8-16-16	ton	$69.20
10-10-10	ton	61.00
0-25-25	ton	76.00
0-15-30	ton	65.80
0-20-0	ton	37.80
Ammonium Nitrate	ton	93.75
Lime	ton	7.00
Corn	cwt.	19.40
Oats	cwt.	7.45
Alfalfa	cwt.	61.80
Orchard S-37	cwt.	69.60
Feed and Grain:		
Milk replacer	cwt.	12.50
Concentrate, 36% protein	ton	90.00
Dairy ration, 16% protein	ton	75.00
Hay	ton	35.00
Livestock and Livestock Products:		
Milk	cwt.	5.00
Cull cows	cwt.	14.00
Calves (3-7 day)	head	10.00
Yearling heifer	cwt.	20.00
Corn	bu.	1.35
Spray:		
2 4-D	gal.	3.70
Miscellaneous:		
Preservative	cwt.	8.00
Feed grinding and mixing	cwt.	.15
Gasoline	gal.	.16
Baler-twine	bale	9.50
Labor	hr.	1.25
Straw	ton	20.00
Custom Rates:		
Corn picking	ac.	5.00
Forage harvesting	hr.	12.00

Appendix Table 4. Yields, Fertilizer Applications, and Seeding Rates for Selected Crops at Two Levels of Fertilizer.

Item	Unit	Corn Grain	Corn Silage	Oats Silage	Alf-Orch Hay
Yield:					
Medium Fert. Level		60 bu.	12 tons	7 tons	3 tons
High Fert. Level		85 bu.	16.5 tons	8 tons	4 tons
Fertilizer Allowance:					
Medium Level					
8-16-16	lbs.	190	190	190	—
0-20-0	lbs.	250	250	—	—
33-0-0	lbs.	—	—	—	—
0-15-30	lbs.	—	—	—	200
0-25-25	lbs.	—	—	160	—
Manure	tons	10	10	—	—
High Level					
8-16-16	lbs.	190	190	190	—
0-20-0	lbs.	250	250	—	—
33-0-0	lbs.	150	150	—	—
0-15-30	lbs.	—	—	—	400
0-25-25	lbs.	—	—	320	—
Manure	tons	10	10	—	—
Seeding Rates:	lbs.	11	11	48	15
Tractor Hours:					
Medium Fert. Level		12.8	11.0	4.2	8.7
High Fert. Level		12.8	11.0	4.2	10.0

Appendix Table 5. Feeding Rates for 1,200 Pound Dairy Cow Producing 10,000 Pounds of 3.5 Percent Milk and for the Replacement on Annual Average Basis.

Item	Quantity
Dairy Cow:	
Concentrates	2,500 lbs.
Hay equivalent	5.8 tons
Replacement:	
Concentrates	560 lbs.
Milk replacer	50 lbs.
Hay equivalent	1 ton

Appendix Table 6. Annual Crop Operating Expenses Per Acre.[a]

Item and Level of Fertilizer	Corn Grain	Corn Silage	Oats Silage	Alf-Orch Hay
Medium Fertilization Level:				
Fertilizer	$11.30	$11.30	$12.65	$ 6.60
Seed	2.10	2.10	3.40	3.25
Fuel and Lub.[b]	5.60	4.80	1.83	3.80
Machine Hire	5.00	12.00	7.50	0
Miscellaneous[c]	.40	.40	.40	6.50
Total	$24.40	$30.60	$25.78	$20.15
High Fertilization Level:				
Fertilizer	$18.33	$18.33	$18.73	$13.16
Seed	2.10	2.10	3.40	3.25
Fuel and Lub.[b]	5.60	4.80	1.83	4.36
Machine Hire	5.00	16.50	9.00	0
Miscellaneous[c]	.40	.40	.40	7.20
Total	$31.43	$42.13	$33.36	$27.97

[a] Computed from data presented in Appendix Tables 3 and 4.

[b] Fuel and lubrication based on 2.6 gallons per hour of operation of tractor with fuel at 16 cents per gallon and lubrication at 2 cents per tractor hour.

[c] Miscellaneous includes such costs as sprays, twine, etc.

Appendix Table 7. Summary of Annual Receipts, Expenses (Excluding Feed and Labor), Per 1,200 Pound Dairy Cow and Replacement.

Receipts:	
10,000 lbs. 3.5% milk @ $5.00/cwt.	$500.00
Cull Cow[a] 240 lbs. @ $14.00/cwt.	33.60
Cull Calves[b]	22.00
Expenses:	
Breeding (artificial insemination)	5.20
Veterinary and medical fees	6.00
Milk testing	6.00
Milk marketing @ 20 cents/cwt.	20.00
Bedding, 1 ton @ $20/ton	20.00
Miscellaneous[c]	11.00

[a] Based on annual replacement rate of 20 percent (1,200 lbs. × 20%=240).

[b] Three out of each 10 calves born are saved for replacements, permitting sale of 7 calves immediately after birth; one of the three replacements is sold at age of one-year. Thus sale culls on a dairy basis includes 0.7 calf at $10 per head and 75 pounds of yearling at $20 per cwt. or $22.00 per year.

[c] Miscellaneous includes such items as equipment and supplies and a death loss of 0.5 percent of total receipts.

Appendix Table 8. Irrigation Costs for 45 Acres of Alfalfa-Orchard Grass.[1]

	Life	Total Cost	Annual Cost
Engine and Pump:			
Gasoline Engine and pump	10 yrs.	$1900	$190.00
Aluminum Pipe:			
1300 ft. of 6" main @ $1.50/ft.	15 yrs.	1950	130.00
850 ft. of 4" lateral @ $1.00/ft.	15 yrs.	850	56.00
Sprinklers:			
12 Medium size @ $9.00 ea.	10 yrs.	108	10.80
Repairs — 2% of Av. Value ($2404) (.02)			48.00
Interest — 5% of Av. Value ($2404) (.05)			120.00
Insurance — Av. Value x Interest Costs ($2404) ($10/1000)			20.00
			$574.80
Fuel — 4.5 gal. per acre inch — .8 acre inches @ .20/gal. for 45 acres			324.00
Oil and grease @ 5% of fuel costs			14.40
Total Initial Cost		$4808	
Total Annual Costs			$913.20
Annual Costs per Acre (excluding labor)			$ 20.29

[1] Based on data from "Technical and Economic Characteristics of Irrigation on Connecticut Farms" by Horace L. Puterbaugh and Marvin W. Kottke, Storrs Agricultural Experiment Station Bulletin 340, March 1959, and "Capital and Labor Efficiency in Irrigation" by Marvin W. Kottke, Storrs Agricultural Experiment Station Bulletin 345, May 1959.

Appendix Table 9. Additional Labor Hours Needed for the Alternatives.[1]

Item	April-May	June-July	Aug.-Sept.	Oct.-Mar.	Total	Hired Labor Required
Excess Labor Presently Available	15	101	22	203	341	
Additional Needed for Alternatives:						
A. Irrigation:						
0.5 response — required	18	116	118	72	324	—
hired	3	15	96	0	—	114
1.0 response — required	42	147	151	168	508	—
hired	27	46	129	0	—	202
B. Green Chop: required	13	187	188	52	440	—
hired	0	86	166	0	—	252
C. Purchase Replacements	0	0	0	0	0	0
D. High Fertilizer: required	54	67	81	216	418	—
hired	39	0	59	13	—	111
E. Corn Silage: required	51	57	9	216	333	—
hired	36	0	0	13	—	49
F. Buy Hay: required	30	25	25	120	200	—
hired	15	0	3	0	—	18
G. Rent Land: required	47	51	63	179	340	—
hired	32	0	41	0	—	73
H. Feed More Grain: required	18	15	15	72	120	—
hired	0	0	0	0	—	0

[1] Based on Appendix Table 2. The amount of hired labor is the difference between the amount required for each period of the year and the excess presently available for each period of the year.

Appendix Table 10. Additional Capital Investment Needed for the Alternatives.[1]

Alternatives	Investment Dollars for Buildings	Livestock	Machinery and Equipment	Total
A. Irrigation				
0.5 response	1,050	1,125	4,808	6,983
1.0 response	2,450	2,625	4,808	9,883
B. Green Chop	700	700	1,588	2,988
C. Purchase Replacements	1,050	300	0	1,350
D. High Fertilizer	3,150	3,600	0	6,750
E. Corn Silage	3,150	3,600	0	6,750
F. Buy Hay	1,750	2,050	0	3,800
G. Rent Land	1,750	2,050	0	3,800
H. Feed More Grain	1,050	1,350	0	2,400

[1] Based on the following rates: Buildings — $350 per cow and replacement; Livestock — $350 per cow, $150 per replacement; Machinery and equipment — refer to Appendix Tables 1 and 8.